

1 We claim:

1 1. A method to select a captain control node from a plurality of
2 interconnected control nodes, comprising the steps of:
3 providing by each of said plurality of control nodes a first signal to each of the
4 other control nodes;
5 receiving by each of said plurality of control nodes, a response signal from each
6 of the other control nodes;
7 calculating by each of said plurality of control nodes individual response times for
8 each of the other control nodes;
9 determining an aggregate response time for each of the plurality of interconnected
10 control nodes;
11 determining whether to select a captain control node using said aggregate
12 response times;
13 operative if the captain control node is selected using said aggregate response
14 times:
15 determining the minimum aggregate response time; and
16 designating the control node having said minimum aggregate response time as the
17 captain control node.

1 2. The method of claim 1, further comprising the steps of:
2 determining if two or more control nodes each have said minimum aggregate
3 response time;

4 operative if two or more control nodes each have said minimum aggregate
5 response time, repeating the steps of claim 1.

1 3. The method of claim 1, further comprising the steps of:
2 calculating by each of said plurality of control nodes a standard deviation for that
3 control node's aggregate response time;
4 providing said standard deviation by each control node to each of the remaining
5 interconnected control nodes.

1 4. The method of claim 3, further comprising the steps of:
2 operative if two or more control nodes each have the minimum aggregate
3 response time, determining which of said two or more control nodes has the smallest
4 standard deviation;
5 designating the control node having the minimum aggregate response time and
6 the smallest standard deviation as the captain control node.

1 5. The method of claim 1, further comprising the steps of:
2 operative if the captain control node is not selected using said aggregate response
3 times, providing a captain control node selection function;
4 determining a performance score for each of the plurality of interconnected
5 control nodes using said captain control node selection function;
6 designating a control node having the minimum performance score as the captain
7 control node.

1 6. The method of claim 5, wherein said captain control node selection
2 function comprises the equation:

3 Performance Score = $a(\text{aggregate response time})^c + b(\text{standard deviation})^d$

4 wherein a, b, c and d are positive constants.

1 7. The method of claim 1, further comprising the step of providing a plurality
2 of host computers, wherein each of said plurality of control nodes is disposed in a
3 different one of said plurality of host computers, and wherein each of said plurality of
4 host computers is capable of communicating with one or more data storage and retrieval
5 systems.

1 8. The method of claim 1, further comprising the step of providing a plurality
2 of data storage and retrieval systems, wherein each of said plurality of control nodes is
3 disposed in a different one of said plurality of data storage and retrieval systems, and
4 wherein each of said plurality of data storage and retrieval systems is capable of
5 communicating with one or more host computers.

1 9. The method of claim 1, further comprising the step of providing a plurality
2 of primary backup appliances, wherein each of said plurality of control nodes is disposed
3 in a different one of said plurality of primary backup appliances, and wherein each of said
4 plurality of primary backup appliances is capable of communicating with one or more
5 data storage and retrieval systems and with one or more secondary backup appliances.

1 10. An article of manufacture comprising a control node and further
2 comprising a computer useable medium having computer readable program code
3 disposed therein to select a captain control node from a plurality of interconnected
4 control nodes, the computer readable program code comprising a series of computer
5 readable program steps to effect:

6 providing a first signal to each of the other control nodes;
7 receiving a response signal from each of the other control nodes;
8 calculating individual response times for each of the other control nodes;
9 determining an aggregate response time for said article of manufacture;
10 receiving an aggregate response time from each of the other control nodes;
11 determining whether to select a captain control node using said aggregate
12 response times;
13 operative if the captain control node is selected using said aggregate response
14 times, determining the minimum aggregate response time;
15 operative if the captain control node is selected using said aggregate response
16 times, designating the control node having said minimum aggregate response time the
17 captain control node.

1 11. The article of manufacture of claim 10, said computer readable program
2 code further comprising a series of computer readable program steps to effect:

3 determining if two or more control nodes each have said minimum aggregate
4 response time;

5 operative if two or more control nodes each have said minimum aggregate
6 response time, repeating the steps of claim 10.

1 12. The article of manufacture of claim 10, said computer readable program
2 code further comprising a series of computer readable program steps to effect:

3 calculating a standard deviation for said aggregate response time for said article of
4 manufacture; and

5 receiving a standard deviation from each of the remaining control nodes.

1 13. The article of manufacture of claim 12, said computer readable program

2 code further comprising a series of computer readable program steps to effect:

3 operative if two or more control nodes each have said minimum aggregate

4 response time, determining which of said two or more control nodes has the smallest

5 standard deviation;

6 designating the control node having said minimum aggregate response time and

7 the smallest standard deviation as the captain control node.

1 14. The article of manufacture of claim 10, said computer readable program

2 code further comprising a series of computer readable program steps to effect:

3 operative if the captain control node is not selected using said aggregate response

4 times, retrieving a captain control node selection function;

5 determining a performance score for each of the plurality of interconnected

6 control nodes using said captain control node selection function;

7 designating a control node having the minimum performance score as the captain

8 control node.

1 15. The article of manufacture of claim 14, wherein said captain control node

2 selection function comprises the equation:

3 $\text{Performance Score} = a(\text{aggregate response time})^c + b(\text{standard deviation})^d$

4 wherein a, b, c and d are positive constants

1 16. The article of manufacture of claim 10, wherein said article of

2 manufacture comprises one of a plurality of host computers, wherein each of said

3 plurality of host computers is capable of communicating with one or more data storage
4 and retrieval systems.

1 17. The article of manufacture of claim 10, wherein said article of
2 manufacture comprises one of a plurality of data storage and retrieval systems, wherein
3 each of said plurality of data storage and retrieval systems is capable of communicating
4 with one or more host computers.

1 18. The article of manufacture of claim 10; wherein said article of
2 manufacture comprises one of a plurality of primary backup appliances, wherein each of
3 said plurality of primary backup appliances is capable of communicating with one or
4 more data storage and retrieval systems and with one or more secondary backup
5 appliances.

1 19. A computer program product usable with a programmable computer
2 processor having computer readable program code embodied therein to select a captain
3 control node from a plurality of interconnected control nodes, wherein said computer
4 program product is disposed in a first control node, comprising:

5 computer readable program code which causes said programmable computer
6 processor to provide a first signal to each of the other control nodes;

7 computer readable program code which causes said programmable computer
8 processor to receive a response signal from each of the other control nodes;

9 computer readable program code which causes said programmable computer
10 processor to calculate individual response times for each of the other control nodes;

11 computer readable program code which causes said programmable computer
12 processor to determine an aggregate response time for said first control node;
13 computer readable program code which causes said programmable computer
14 processor to receive an aggregate response time from each of the remaining control
15 nodes;
16 computer readable program code which causes said programmable computer
17 processor to determine whether to select a captain control node using said aggregate
18 response times;
19 computer readable program code which, if the captain control node is selected
20 using said aggregate response times, causes said programmable computer processor to
21 determine the minimum aggregate response time; and
22 computer readable program code which, if the captain control node is selected
23 using said aggregate response times, causes said programmable computer processor to
24 designate the control node having the minimum aggregate response time as the captain
25 control node.

1 20. The computer program product of claim 19, further comprising:

2 computer readable program code which causes said programmable computer
3 processor to determine if two or more control nodes each have the minimum aggregate
4 response time;

5 computer readable program code which, if two or more control nodes each have
6 the minimum aggregate response time, causes said programmable computer processor to
7 repeat the steps of claim 19.

1 21. The computer program product of claim 19, further comprising:
2 computer readable program code which causes said programmable computer
3 processor to calculate a standard deviation for said aggregate response time for said first
4 control node;

5 computer readable program code which causes said programmable computer
6 processor to receive a standard deviation from each of the remaining control nodes.

1 22. The computer program product of claim 21, further comprising:
2 computer readable program code which, if two or more control nodes each have
3 the minimum aggregate response time, causes said programmable computer processor to
4 determine which of said two or more control nodes has the lowest standard deviation;

5 computer readable program code which causes said programmable computer
6 processor to designate the control node having the minimum aggregate response time and
7 the lowest standard deviation as the captain control node.

1 23. The computer program product of claim 19, further comprising:
2 computer readable program code which, if the captain control node is not selected
3 using said aggregate response times, causes said programmable computer processor to
4 retrieve a pre-determined captain control node selection function;

5 computer readable program code which causes said programmable computer
6 processor to determine a performance score for each of the plurality of interconnected
7 control nodes using said captain control node selection function;

8 computer readable program code which causes said programmable computer
9 processor to designate a control node having the minimum performance score as the
10 captain control node.

1 24. The computer program product of claim 23, wherein said captain control
2 node selection function comprises the equation:

3
$$\text{Performance Score} = a(\text{aggregate response time})^c + b(\text{standard deviation})^d$$

4 wherein a, b, c and d are positive constants